10/559920

IAP8 Rec'd PCT/PTO 08 DEC 2005

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Augsburg

17.06.2003

Procedure for layered composition of models

This invention involves a procedure for layered composition of models.

State-of-the-art examples of this procedure include rapid-prototyping manufacture of moulds and casting models without a use of tools.

For instance, DE 198 53 834 A1 describes a rapid-prototyping procedure for creating cast models. In this case, an untreated particle material like quartz sand is applied in a thin layer to an assembly platform. After that, a spraying mechanism is used to finely distribute a bonding agent over the entire particle material. Selected areas of the resulting surface are subsequently covered with hardener to reinforce the particle material wherever required. Repeating this whole process several times permits a structure to be shaped individually from the bonded particle material. This structure is initially embedded in the encompassing, unbound particle material and can be removed later following completion of the assembly process.

For example, if this type of rapid-prototyping procedure makes use of quartz sand as the particle material and furan resin as the bonding agent, sulphuric acid as the hardener makes it possible to create a mould consisting of materials

normally employed during mould production and therefore familiar to experts.

The binder largely consists of furfuryl alcohol, nitrogen, water and free formaldehyde. Concentrated sulphuric acid is normally used as the activator.

A major disadvantage of moulds so manufactured are the environmentally harmful constituents of the binder material. This results in complex handling and recycling of such material, especially during actual mould manufacture, casting, de-moulding and disposal of the casting sand.

During casting, the organic binders are decomposed into gaseous substances. This gas formation can negatively affect the cast component by allowing gases to permeate the metal and make the workpiece porous. This can notably worsen component quality.

In the case of such modelling, however, it is important for the binder to decompose into organic substances in order to permit subsequent coring of the cast metal part.

Furthermore, the crack products arising during decomposition of the binder are environmentally harmful and need to be disposed of appropriately.

Demoulding of the cast part can require a great deal of energy, because the binder needs to be destroyed thermally before it can be removed from the cast part's cavities.

The sand employed as the particle material must be reconditioned thermally after casting, i.e. residual bonding

agent must be combusted through intense heating of the sand. This, too, requires a lot of energy and also gives rise to environmentally harmful reaction products. Alternatively, the sand can be deposited on landfills, although this measure is not very environmentally compatible either.

In general, however, organic binders can be integrated very favourably into layering techniques. A multi-component resin is usually employed for this purpose. In addition to the afore-mentioned option of selectively applying two components in succession to the untreated sand, it is also possible to mix a reaction component into the sand and selectively dose a second component. Either this proves sufficient for a subsequent, selective combination of the sand particles, or additional use is required of thermal energy or a reactive gas during / after the assembly process.

US 5.204.055 proposes manufacture of metal moulds via 3-D pressing. Here, the basic material comprises aluminium oxide ceramic particles, the bonding agent a colloidal silica suspension. Due to poor coring properties, however, this material system is unsuitable for sand casting, and exhibits notable discrepancies with respect to the usual sand casting characteristics.

Moulds so produced possess a certain green strength after assembly. To achieve their final strength, the moulds must undergo thermal transfer. In this process, cracks can occur in the moulds, or the component dimensions can change as a result of contraction.

In such cases, demoulding of the cores is performed in a special solution or by means of a water jet.

As experts will know, Z-Corp. uses a gypsum-based system for manufacturing moulds. One disadvantage of this type of material is the divergence of its casting properties from those of sand casting; there are no similarities here.

The invention under consideration is accordingly intended to provide a procedure for layered composition of models - i.e. moulds and cores - making use of environmentally friendly bonding agents fulfilling specified criteria for moulded material such as strength and stability. Moreover, the casting properties are to be similar to those of conventional sand casting.

This is accomplished by a procedure for layered composition of models, whereby at least a first material is applied to an assembly platform, followed by selective application of a second material layer; these two application steps are repeated until the required model is achieved and both materials form a solid structure in an appropriate mixture ratio. The first material comprises a moulding sand; the first and/or second material comprises a bonding agent encompassing a salt-crystal binder and/or protein binder.

Salt-crystal or protein bonding agent used in a procedure for layered composition of models is characterized, in particular, by its environmental compatibility during production, mould handling, casting and disposal.

Furthermore, this type of procedure in conjunction with moulding materials commonly used in foundries makes it possible to achieve models with very good material

characteristics highly similar to those associated with sand casting.

After casting, the resultant component can be demoulded very easily through immersion in water or shaking. This is permitted by the high water solubility of salt-crystal binder.

In a preferred embodiment of the procedure forming part of this invention, the bonding agent is mixed into the first material.

The first material in the procedure forming part of this invention is expediently a mixture comprising bonding agent and moulding sand.

This makes it possible to add a type of salt to the sand. Water is then added selectively to the resultant mixture. The salt dissolves in the water to encompass the sand. After the sand has dried, the salt crystallizes to bind the sand particles.

This material's behaviour during casting is absolutely neutral. The salt's melting temperature is notably higher than that of the metal, thus preventing a generation of gases during casting. However, the moulded material needs to dry optimally to prevent boiling retardation. For this purpose, conventional core-shooting techniques make use of microwave radiation to dry the core. This would also be possible for the procedure forming part of this invention. The model can furthermore be purged with warm air.

After casting, the mould can be cored through immersion in water, which dissolves the salt and related bond.

The sand can be re-used after casting. Yet another advantageous casting property here is the neutral odour compared with organic bonding agents.

In the procedure forming part of this invention, it is also possible for the moulding sand to be coated with the bonding agent.

In a preferred embodiment of the procedure forming part of this invention, the bonding agent is mixed into the second material.

Good results are achieved if the first material comprises moulding sand, the second material a solvent.

If the solvent essentially comprises water, it is fully compatible with the environment and very economical.

It is preferable for the second material to be applied by means of droplet generation.

In addition, it is possible for the second material to be applied by means of screen printing or spraying through a template.

In the procedure forming part of this invention, it is especially preferable for the solvent to be removed through drying after an appropriate reaction time has elapsed.

In the procedure forming part of this invention, the moulding sand preferably comprises quartz sand, zircon sand, olivine sand and/or fireclay sand.

The bonding agent in the procedure forming part of this invention is based preferably on magnesium sulphate, sodium polyphosphate and/or protein.

The described procedure forming part of this invention has proven particularly suitable for manufacturing components serving as moulds for metal casting.

Examples of preferred embodiments below are used to describe the invention more closely.

A procedure for layered composition of foundry moulds according to this invention is described in the following.

In contemporary procedures, binder is mixed with basic mould material - usually comprising quartz sand - and applied in thin layers using a coater to defined areas of a lowerable assembly platform. A computer-controlled pressure head applies activator to the porous sand layer over the required cross-sectional areas of the component to be generated. The final component is achieved successively by repeating this entire process, i.e. lowering the assembly platform by one layer thickness unit, applying a thin layer of sand and binder, and selectively dosing activator.

According to the invention, the bonding agent comprises a salt or protein binder.

The binder can either be pre-mixed with the sand prior to layering, or added as particle material to the sand. Moreover, it is possible to selectively apply the binder in a solution and/or dilution by means of a dosage head in accordance with the cross-sectional profile which needs to be achieved.

The bonding agent can be employed in a variety of ways as part of the layering process. For example, it can be mixed in the form of solid particles with the sand. The resultant mixture is then applied in layers to an assembly field. After that, water or a solvent is applied by means of a droplet generator (alternatively: screen printing, spray through a template) to the required cross-sectional areas of the component. After a short reaction time, the water is removed through drying (passive drying, microwave radiation, heat radiation, warm air stream etc.). The entire process is repeated by lowering the assembly platform and applying a new layer.

It is also possible to remove the water from the bond after completion of the entire assembly process, although this poses a danger of diffusion which can disperse the component's geometry.

Another option is to coat the sand with the binder prior to the process and employ it as described above.

Yet another possibility is to apply a mixture of binder and water to untreated sand.

In all procedural variants, the resultant model is freed of surrounding material after the assembly process, and the sand made available for recycling.

It is important to dose the solvent in the exactly required quantities. On one hand, sufficient solvent should be dosed to bind the particles mutually and with the underlying layer. On the other hand, the solvent dosage should be kept within certain limits to prevent undesired diffusion and resulting impairment to the model's outline and accuracy.

Particularly good results are achieved if the first material comprises a moulding sand like quartz sand and 1.8% by weight of LaempeKuhsBinder® (a binder made by Laempe). The second material dosed in the preferred embodiment exemplified at the start comprises 3% by weight of water.

GMBond protein binder from Hormel is particularly suitable for the foundry applications associated with the procedure forming part of this invention.

Quartz sand is highly suitable as a basic material also when mixed with protein binder.